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Agricultural Research

When it storms at Walnut Gulch

Setting the Table for Research

For quite a few years now, leaders in agricultural science have been emphasizing the need for more research into the fundamental components and processes of life. A broader base of biomolecular knowledge is critical, they say, to the continued progress and vitality of applied research—research in crop genetics or pest control, for example, which directly supports the production and quality of food and fiber and the protection of the environment.

Others have argued that the tangible payoffs for basic research are often too far down the road and that research on the more practical side of things must be emphasized—even at the expense of basic research—in today's policy-driven science with its attendant political and financial pressures.

There are, of course, no clear lines of demarcation between basic and applied research. What's basic in one sense may be applied in another, and in agricultural science the two are so likely to merge that repeatedly distinguishing between them seems academic if not pointless. Suffice it to say that the Agricultural Research Service promotes both kinds of research to the fullest extent possible.

ARS also promotes a kind of scientific research that is neither basic nor applied. Nor is it necessarily a combination of the two. Sometimes it's called technique-oriented science, but it's often more than that.

To give this work its due, it can be depicted as a noble servant: research that quietly and dutifully sets the table for other research. It is research that provides the instrumentation, techniques, data, and materials that make a lot of other basic and applied research projects in agriculture possible.

Two stories in this issue of Agricultural Research, while worlds apart in specific subject matter, provide examples of table-setting research. One story is on instrumentation and related techniques for investigating tissue at the cellular, molecular, and submolecular levels. The other concerns the collection of hydrologic and spectral energy data over semiarid rangelands for research in aerospace remote sensing.

At the Electron Microscopy Laboratory (EML) in Beltsville, Maryland, scientists are developing ways to make their new scanning tunneling microscope more suitable for research in molecular biology. Normally used to examine metallic and other nonorganic surfaces, the scanning tunneling microscope is capable of profiling the electron clouds or shells of individual atoms and could prove invaluable to USDA's proposed plant genome research program.

The EML has also modified a standard cryostage and specimen holder for a conventional scanning electron microscope so that frozen tissue can be placed closer to its lens and electron collector. This has resulted in micrographs with a tenfold increase in resolution—in other words, images with more detail than ever before.

Another EML project, the computerized digitation and colorization of optical and electron microscope imagery, will help researchers quantify such phenomena as membrane changes in plant cells that are exposed to ozone.

Shifting the scale of things from micro to macro, the Walnut Gulch Basin in southeast Arizona is the focus of research on the hydrologic cycle and energy balances of semiarid rangelands suddenly hit by hard rain. The extensive and detailed data collected at numerous sites throughout the basin last summer will help scientists establish a definitive "ground truth" for interpreting satellite surveys of semiarid rangelands in America and around the world. The data will also be tapped for years to come by scientists studying surface energy interactions with the atmosphere and their impact on regional and global warming trends.

Whether it yields new studies of subjects measured in miles or new images of subjects measured in micrometers, the scientific work in Walnut Gulch and at the EML has set some big tables for research in the future. But it only begins to suggest the extent and diversity of such research in ARS.

Monoclonal antibodies created by ARS animal scientists have accelerated the progress of research to combat parasites and diseases of livestock. ARS has also pioneered the adaptation of monoclonal antibody technology to plant science. One monoclonal antibody, created by the ARS Florist and Nursery Crops Laboratory, can detect 100 different viruses that attack plants. It is also being used to study nitrogen fixation and photosynthesis.

Tissue culture techniques developed by ARS have proven extraordinarily useful in plant breeding and genetic engineering research, particularly in studies of the environmental and genetic mechanisms behind tissue differentiation and cell mutation. The rapid asexual propagation of virus-free plant material in tissue culture has also enabled scientists to study the regeneration of plants from the products of protoplast fusion and other genetically altered tissue. And it has opened new doors to the development of disease-resistant and herbicide-tolerant crop varieties.

There are many other examples.

The use of airborne lasers to profile ephemeral gullies for soil erosion estimates, the engineering of whole body calorimeters for human nutrition studies, the application of mass spectrometry to plant hormone measurements—the list is indeed long when it comes to cataloging ARS contributions to the methods and techniques of scientific research. Perhaps their projects aren't always considered headliners, but the table setters in ARS and elsewhere have the attention and applause of the entire scientific community.—**Stephen Carl Miller,** ARS.

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Cover: As summer thunderstorms electrify the Arizona sky, scientists gather data on the hydrologic cycle and spectral energy balances of semiarid rangelands suddenly hit by hard rain.
© Photo by William L. Wantland, Tucson, Arizona

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When The Hard Rains Come

Tracking Their Fate In Tombstone Territory

They come every summer, the dark clouds do, rolling north from Mexico to bring torrential rains and world-class thunderstorms into the American Southwest.

The locals call them monsoons, and that's what they are. The late afternoon and early evening cloudbursts triggered by rising currents of hot air are the same, at least meteorologically, as those that hit India, Southeast Asia, and the Tropics.

Flash floods and frequent lightning are constant threats, and two rules govern the day: sit tight and let them pass.

In the summer of 1990, however, nearly three dozen scientific investigators were ready and waiting—in the Walnut Gulch Basin surrounding Tombstone, Arizona—with everything from rain gauges to multispectral radiometers to airborne synthetic aperture radar.

Three airplanes equipped for remote sensing (measuring the spectral energy, or heat, light, and microwaves reflected or emitted from soil, water, and plants) were also on hand.

And three satellites, similarly equipped, were looking in as well.

This was it: the main event of an interdisciplinary, interagency, and international scientific operation that Agricultural Research Service

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Using multispectral radiometers, an international group of scientists collects ground energy data over an area matching that recorded by aircraft and satellite. (K-3746-15)

JACK DYKINGA

University of Arizona graduate student Jim Washburne displays rainfall distribution data for the Walnut Gulch watershed. (K-3747-13)

hydrologist William P. Kustas had been planning for well over a year.

The name of the operation: Monsoon 90. Its timeframe: late July to mid-August, the peak of the Southwest's monsoon season. Its mission: to fully document what happens to semiarid rangelands suddenly hit by a lot of hard rain.

After Each Storm

If everything went as planned, the research in Walnut Gulch would contribute immensely to the use of remotely sensed data for monitoring semiarid rangelands in the United States and around the world.

"We were there," says Kustas, "to get a complete picture of the hydrologic cycle of the basin during the monsoons—to follow every raindrop, so to speak, every step of the way."

After each storm, scientists at sites throughout the Walnut Gulch Basin measured rainfall, runoff, water movement into and through the soil, soil moisture levels, evaporation from the soil, water uptake by plants, evaporation from plant leaves, and other factors vital to tracking the natural distribution, circulation, and overall fate of precipitation.

At about the same time, remote sensing instruments on aircraft and satellites were aimed at the sites. Data from these instruments would be compared to spectral energy readings taken on the ground and direct hydrological measurements.

"By comparing the data from above with our findings at ground level," says Kustas, "we can further establish the potential of aerospace remote sensing as a tool for water management—especially in semiarid regions of the country. In these regions, water supplies and their replenishment by monsoons are critical issues."

Monsoon 90

What happens to semiarid rangelands hit by a sudden hard rain.

Can satellites actually reveal how well the soil has been resupplied with rainwater? "Not directly," Kustas says. "But we believe the right combination of spectral energy readings from soils and plants on the surface can produce reliable estimates of the amount of water below."

Shifting Energy Balances

Of particular concern to Kustas and his Monsoon 90 colleagues are the effects of sudden precipitation on the transfer of surface heat and moisture into the atmosphere.

An increasing body of scientific evidence suggests that relatively small, localized changes in such surface-atmospheric interactions can influence the climate regionally and perhaps on continental scales. Changes in heat energy levels at the surface are critical to the process.

"There are two kinds of heat involved here," explains Kustas. "One is what we call sensible heat. It's the kind of heat you can feel, like the warmth of the sun or the ground heated by the sun. The other is latent heat, which is sensible heat energy stored in another form."

Evaporated water, or vapor, can be thought of as latent heat. Vaporized water is the largest source of latent heat energy from the Earth's surface to be gained by the atmosphere for eventual use in faraway places.

"It's not very poetic," says Kustas, "but that's what clouds are—accumulations of latent heat energy being transported over long distances. This energy is released via condensation, ultimately getting back to us in the form of rain."

Although oceans provide most of the planet's atmospheric vapor, it appears that both sensible and latent heat from the land play a major role in determining when and where the rain will fall. If so, then reliable remote sensing data on the energy balances of semiarid rangelands could become a vital part of meteorological science.

"If we want to make the most of our remote sensing capabilities to anticipate changes in climate on a

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◀ **Meteorologist Tracy Grant and student assistant Scott Cartwright, foreground, prepare to launch an instrumented tethered balloon to measure weather information. (K-3742-5)**

▶ **Part of NASA's C-130 team awaits a break in weather before flight to record microwave emissions from the soil. (K-3748-1)**

regional and even global scale," says Kustas, "then we must learn how to monitor the hydrologic cycle of semiarid rangelands more fully and accurately than ever before."

Considering the fact that roughly 40 percent of the Earth's land surface is broadly classified as rangeland, and that 80 percent of these rangelands fall within arid and semiarid zones, it's easy to see why.

Analyzing the Data

Kustas is now back at his home base: the ARS Hydrology Laboratory in Beltsville, Maryland. The mud from his boots has long since been scraped off, the monsoons are over, and the rangelands in the Walnut Gulch Basin are dry again. But Monsoon 90 is still going strong.

"You might say it's really just beginning," he says. "All our soil moisture measurements, our spectral energy readings, every record we've got from out there, everything—it's all raw data. And we've got a ton of it, ready to be analyzed and compared and contrasted in just about any way imaginable."

Using a powerful spatial analyis technique called geographic information systems in which a computer tags each piece of data with precise latitude and longitude coordinates and then generates a composite picture, scientists will analyze large areas in Walnut Gulch as well as data from individual test sites. The technique is especially useful for the examination and comparison of topographies, soil types, soil moisture, and vegetation.

Records from each site in the Walnut Gulch Basin are also being forwarded to the ARS Water Data Center, a vital part of Beltsville's Hydrology Laboratory. The center operates as a collecting point and clearinghouse for all ARS data from watersheds throughout the United States. In doing so, it maintains a nationwide databank called REPHLEX—Retrieval Procedures for Hydrologic Data from Experimental Watersheds.

Nearly one-fourth of the REPHLEX system's on-line storage capabilities will be taken up by Monsoon 90, according to Jane Thurmon, director of the Water Data Center.

"We may very well have to expand our capabilities in order to handle everything they're sending from Walnut Gulch," she says. "It's difficult to say at this point. But I can say, without qualification, that this will be the most diverse set of data we have ever managed at the center."

The Perfect Place

The Walnut Gulch Basin, an elongated 58-square-mile watershed draining into the San Pedro River, sits 60 miles southeast of Tuscon near the southeast corner of Arizona. Its gently rolling hills and grass-brush rangelands are typical of that part of the country and get 10 to 20 inches of rain a year, two-thirds of it during July and August.

Although the monsoons and their immediate hydrological impact have never before been studied from a

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remote sensing perspective, the entire area has been the subject of intense hydrology research for decades.

"That was a major consideration in selecting Walnut Gulch for Monsoon 90," Kustas points out. "No other watershed in the world—at least no other semiarid watershed of comparable size—has so much hydrological instrumentation or such a lengthy and complete set of hydrological records."

A large experimental area was needed, adds Kustas, in order to assess the full impact of the monsoons on the hydrologic cycle and subsequent changes in surface energy balances and climate.

Rain gauges, runoff measuring flumes, and meterological stations were installed throughout the Walnut Gulch Basin by the ARS Aridland Watershed Management Research unit nearly 25 years ago. The unit, which is headquartered in Tuscon with auxillary facilities in Tombstone, has published over 100 scientific papers describing the basin's climate and precipitation characteristics.

In addition to monitoring the watershed as a whole, the unit maintains 22 highly instrumented subwatersheds within the basin that provide detailed hydrological data relating to different kinds of terrain.

"The records for Walnut Gulch are proving invaluable to our interpretation of data from the monsoon period," Kustas says. "They provide us with an excellent frame of reference. Without them, we might miss the significance of certain shifts or changes in the hydrologic cycle."

Working Together

After preliminary visits in the spring for test site inspections and assorted logistical arrangements, Kustas returned to Walnut Gulch in the latter part of July. It was already raining, but the real storms, the gully washers from Mexico, hadn't blown in yet. In any event, he arrived just in time to make sure that a series of soil moisture tests in the basin coincided with remote sensing activity by a satellite passing over the area.

For the next 4 weeks, Kustas would coordinate the field work and data collection of all participants in Monsoon 90. In addition to projects by colleagues from ARS, studies in the basin were undertaken by scientists from the National Aeronautics and Space Administration (NASA), the U.S. Geological Survey, Los Alamos National Laboratories, the Jet Propulsion Laboratory, Utah State University, the Universities of Arizona and Maryland.

Scientists from France and the Soviet Union were also there.

"We really depended on each other," Kustas says. "The data from any one site or experiment could be highly significant in the interpretation of data from other sites. Everything had to fit together."

Generally, the projects in Walnut Gulch fell within five categories of hydrological research: precipitation and runoff, soil moisture, meteorological and low-level atmospheric conditions, ground-based evapotranspiration measurements, and spectral energy readings taken at ground level and from aircraft and satellites.

•ARS, NASA, and the University of Arizona were responsible for

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obtaining all spectral energy readings at ground level and from aircraft and satellites. The ARS Water Conservation Laboratory in Phoenix and the Hydrology and Remote Sensing Laboratories in Beltsville took the lead in this effort. Several scientists from France helped calibrate the instruments and collect the data.

•University of Arizona researchers also measured the effects of water vapor on the optical depth, or opacity, of the atmosphere in terms of its effect on satellite imagery.

•The U.S. Geological Survey measured cloud cover as well as evaporation and water vapor at ground level.

•Los Alamos National Laboratories and Utah State University monitored air temperatures, moisture levels, air currents, and other characteristics of the troposphere (lower atmosphere) from the surface up to several thousand feet in order to determine their effects on remote sensing data.

•Scientists from the Soviet Union brought in a new kind of airborne radiometer designed to simultaneously measure three distinct bands of microwave emissions from the ground. Monsoon 90 provided an ideal testing ground for their radiometer, they said.

Although the instrument was able to detect only two of the three frequencies, the Soviets showed that such an approach was more accurate than conventional single-band measurements in estimating soil moisture.

•Flying a NASA DC-8 jet equipped with synthetic aperture radar (SAR) that produces one continuous ultra-high-resolution image based on radar reflections from the ground, the Jet Propulsion Laboratory obtained data for experimental wide-area surveys of soil moisture and vegetation height and density. The SAR system is a prototype of that planned for use in future space shuttle missions—and on the space platform as well—and the flights over Walnut Gulch were designed in part to test its potential for this type of soil moisture and biomass mapping.

•University of Maryland investigated ways of using satellite data to determine the amount of solar energy reaching the surface.

Airborne Measurements

As usual in the hot summer of the southwest, the storms in Walnut Gulch occurred in the late afternoon.

> "We're developing a huge database, and scientists from all over the world will be drawing from it for years to come."

This provided time for several remote sensing surveys from aircraft before each storm.

By sunrise, a low-altitude flight had already been made to record natural microwave emissions from the soil. This radiation, produced by

◀ **Before a thunderstorm reaches the site, hydrologist William Kustas checks instruments at one of the eight weather stations in the watershed. (K-3743-14)**

▶ **Using time-domain reflectometry, hydrologic engineer Leslie Bach measures soil moisture content at multiple depths. (K-3745-11)**

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the interactions of water molecules and thermal energy stored in the soil, is an accurate indicator of soil moisture levels.

Other flights were made in the early morning, midday, and late afternoon to record solar heat reflected from the surface of the ground and the radiation of solar heat stored by the ground. Combined with the data on soil moisture, the thermal reflectance and radiation data will help scientists quantify the effects of rain on the movement of heat from the ground into the air.

Also tested during Monsoon 90 was an experimental airborne laser system for measuring the amount of ground covered by vegetation. Originally developed for oil explorations but modified by ARS for detecting and profiling ephemeral gullies, the system beams a rapidly pulsating laser to the ground from a low-flying aircraft and records the degree to which each pulse is reflected. A weak reflection indicates vegetation.

Precipitation and runoff data were collected from rain gauges and runoff flumes at sites throughout the basin by technicians from the Southwest Watershed Research Laboratory. Soil samples from the same sites were regularly weighed, baked until dry, and weighed again to determine soil moisture. This data was used to calibrate the microwave-sensing instruments used in experiments to measure soil moisture from the air.

A tethered weather balloon provided vapor, windspeed, temperature and other atmospheric data up to 500 meters. In addition to profiling atmospheric conditions, data from the balloon was used in the adjustment, correction, and overall processing of spectral data from aircraft and satellites.

Not Many Answers—Yet

What have the scientists from Monsoon 90 learned? Do they have new information that will make a difference in rangeland water management, or the science of hydrology, or remote sensing?

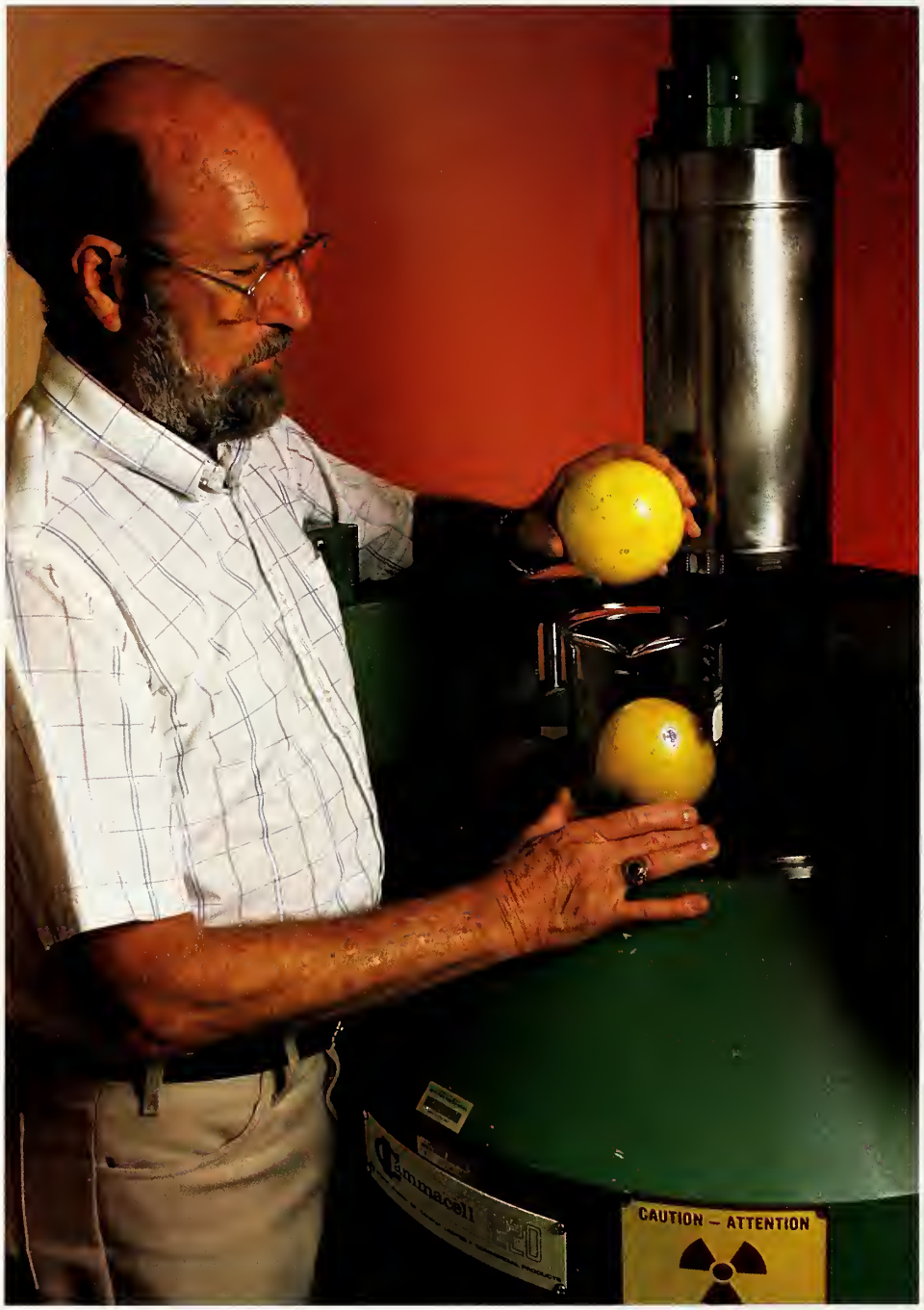
"We do have some preliminary findings that might be considered new," Kustas says. "For example, we've found soil moisture levels after heavy rains to be more uniform over larger areas than previously expected. That kind of information, when looked at more closely, could have an impact on the use of remote sensing in flood prediction."

Kustas emphasized, however, that answers to most questions about remote sensing and the fate of rainwater on semiarid rangelands aren't likely to be forthcoming from Monsoon 90 in the immediate future.

"We're developing a huge databank," he says, "and scientists from all over the world will be drawing from it for years to come. Some results may wind up in scientific journals within a year or so, but we'll be seeing significant studies based on what we did in Walnut Gulch well into the next century."—By **Stephen Carl Miller,** ARS.

William P. Kustas is at the ARS Hydrology Laboratory, Bldg. 265, BARC-East, Beltsville, MD 20705 (301) 344-2498. ◆

PERRY A. RECH



Research entomologist Don von Windeguth places grapefruit into position for irradiation. (K-3801-1)

A New Look at Irradiated Citrus

Besides treating grapefruit, a commercial firm in Florida plans to use irradiation to extend the shelf life of strawberries and mushrooms and to eliminate *Salmonella* bacteria in about 20 million pounds of poultry a year.

Irradiation has always been a scary word to U.S. consumers. But it needn't be, say Agricultural Research Service scientists.

"People usually associate irradiation with radioactivity," says entomologist Donald L. von Windeguth. "That isn't true in the case of irradiated food. Irradiated food is completely safe for consumption. It does not expose a consumer to radiation."

And he should know. At the ARS Subtropical Horticulture Research Laboratory in Miami, Florida, he irradiates citrus to kill fruit flies. He's been doing it for over 20 years.

At first, his work didn't receive wide attention. But after the U.S. Environmental Protection Agency (EPA) banned the use of ethylene dibromide (EDB)—the only effective quarantine treatment against fruit flies at the time—an alternative was desperately needed.

"Although a fairly new concept to consumers, food irradiation has been researched by the federal government for over 40 years," he explains. "We simply need to better inform the public about what it really means."

Federal officials suggested irradiation to the citrus industry as a safe, nonchemical alternative to EDB in plant quarantine situations, according to Dan Gunter, executive director of the Florida Department of Citrus. "But though the citrus industry understands the merits of irradiation, the public appears to be skeptical."

Currently, citrus must be quarantined before it can be shipped to an area free from the fruit fly.

"We did our own research that proved that irradiation of quarantined citrus is an effective way to prevent spread of the fruit fly," Gunter says. However, there are as yet no facilities to apply the technology, which would be fairly expensive.

In addition to using an approved cold treatment, industry takes advan-

tage of fly-free zones—citrus-growing areas that the U.S. Department of Agriculture has certified as free of the fruit fly.

Von Windeguth contends that irradiation is more effective than the cold treatment. "It's the only treatment that causes the larvae to come out of the fruit."

The irradiator, a round machine about 5 feet tall, contains 20 pencils of cobalt arrayed in a circle that's surrounded by a lead shield. Placed in a cylinder that extends above the machine, the fruit is locked in and lowered into the radiation chamber. Exposure, usually only a few seconds, affects insect eggs and larvae buried in the fruit. If larvae are present, they'll crawl out of the fruit after treatment. If they pupate, adults are unable to emerge. Metabolic changes caused by the radiation kill most insects in the pupal stage.

All other acceptable quarantine treatment—hot water baths, vapor, and cold temperatures—kill the pests inside the fruit.

"Irradiation leaves no residue, passing through the fruit like a ray of light," von Windeguth says.

Passing through the fruit as it does, radiation disrupts the insect's development. This kills the insect before it fully develops. In some foods, radiation also prolongs shelf life and retards ripening.

Sam Whitney, president of Vindicator of Florida, Inc., Plant City, Florida, is making irradiation more available to the citrus industry. His company will open a plant in Mulberry, Florida, in May of 1991; Whitney plans to irradiate about 6 million cartons of grapefruit a year.

"We expect the cost to be about a penny per pound of grapefruit, only slightly more than it would have cost to use EDB," Whitney says.

This is the first commercial facility in the United States dedicated solely to food irradiation.

"I favor irradiation to disinfest citrus," Whitney says. "Not only is it more effective, but it can be used on all types of fruit, even early types that can't take the cold treatment."

Besides treating grapefruit, the firm, Vindicator of Florida, plans to use irradiation to extend the shelf life of strawberries and mushrooms and to eliminate *Salmonella* bacteria in about 20 million pounds of poultry a year.

When Vindicator's plant is up and running, von Windeguth may feel that his perseverance has paid off.

"I started irradiating citrus back in 1973, even before EPA banned ethylene dibromide," he muses. "Now that so many major agricultural chemicals have been taken off the market because of their hazard to human health and the environment, this nonchemical alternative will hopefully be given a chance."

Other countries, including Japan, China, the Soviet Union, the Netherlands, and France, have been irradiating food for years.

Von Windeguth has successfully used radiation on grapefruit and mangoes. Treatments have been approved as quarantine measures.

He has used trained taste panels to evaluate the irradiated fruit. In a test at Orlando, 12 panelists preferred irradiated fruit, 11 preferred control fruit, and 10 had no preference. And although irradiation can affect the flavor and texture of food, Von Windeguth says consumers would probably not be able to tell the difference between irradiated and untreated fruit.

Along with colleague Walter P. Gould, an entomologist at the Miami lab, he has combined cold treatment with irradiation to combat the Caribbean fruit fly in carambola. While results are promising, further tests are planned that will include transportation and storage conditions.

"I'm anxious to see how Sam Whitney's plant does," von Windeguth says. "I still think that it's possible for the citrus industry to have some type of irradiation unit online at the packinghouse."—By **Doris Stanley,** ARS.

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PERRY A. RECH

Over 20,000 fruit fly eggs call this gauzelike strip of growth medium home. (K-3803-1)

How Do You Grade Wild Rice?

Wild rice makes a delicious pudding, a tasty stuffing for your holiday turkey, and an ideal base for casseroles made from those endless turkey leftovers.

Right now, the nutty-tasting wild rice you buy at your supermarket is checked for wholesomeness but typically isn't graded by government inspectors.

In the future, however, that might change. Many U.S. growers and processors say the uniformity and consistency offered by nationally accepted inspection and grading could be a boon to their industry.

Consumers too could benefit. When they reach for a box, bag, or scoop of USDA-inspected and -graded wild rice, they'd have a better idea of the quality and value of rice they're buying.

In California, where production of wild rice is an $8-million-a-year industry, growers asked ARS scientists to provide accurate, reliable ways for grain inspectors to weigh, measure, and judge harvested rice.

Those techniques, now outlined in easy-to-follow steps, could become part of a future USDA- or industry-regulated inspection and grading system. It could be used voluntarily by the U.S. wild rice industry, according to ARS' Albert P. Mossman and Robert N. Sayre at the Western Regional Research Center in Albany, California.

Mossman and Sayre tested and refined techniques for scrutinizing wild rice in two forms—freshly harvested or "green" grain and processed rice—glossy black or light brown kernels ready for cooking.

To make sure that the techniques would work for wild rice grown anywhere in the United States, the two scientists worked with growers and processors in the two leading rice producing states—California and Minnesota. The steps outlined by the researchers describe how inspectors should collect, store, clean, dry, shell, and measure each sample.

Now it's up to the industry, with advice from USDA's Federal Grain Inspection Service, to agree on what grades or classifications—like "grade A premium"—to use for grading the inspected rice.

"Even though there are no national standards for measuring and grading wild rice," says Mossman, "some growers and processors have developed their own, unofficial standards, using tests that range from very rough to fairly precise.

We took some of these tests and built on them, making modifications in the laboratory. So that the tests would be practical, we also tried to stay with the same equipment that some of the producers already use or that inspectors have on hand for checking white rice."

Inspectors could analyze 10 samples of green wild rice in about 2 hours. Ten samples of processed rice—the kind you buy at the store—would take about half as much time.

If growers and processors nationwide can reach an agreement on grading, it will take some 3 to 5 years to put a federally approved grading system into place, says John Mack Manis of USDA's Federal Grain Inspection Service.

If that were to happen, processors who buy rice from more than one source could count on wild rice's quality and characteristics within each grade to be consistent from one supplier to the next.

"Uniformity is especially important to companies that prepare packaged mixes," explains Mossman. "If there's too much variation in wild rice, the cooking time that's printed on the box won't work out—you'll end up with some overcooked, mushy grains and some that are undercooked and too chewy."

Grading might boost the industry's competitiveness with Canada in export markets. "Standards take some of the risk out of buying a commodity at a distance, sight unseen," says Mossman, "so the export market is a strong incentive for the industry to adopt a national set of standards."

Even though it looks like rice, wild rice isn't really a rice at all—it's a grass (*Ziznaia* species). This native grain grows on soggy soils—in lakes, rivers, streams, and swamps as well as in manmade paddies.

Although most commercial wild rice is raised in paddies and machine-harvested, some is laboriously harvested by hand from wild stands—in keeping with the traditions of the Chippewa and other Native Americans.—By **Marcia Wood,** ARS.

Albert P. Mossman and Robert N. Sayre are with the USDA-ARS Western Regional Research Center, Food Quality Research Unit, 800 Buchanan Street, Albany, CA 94710 (415) 559-5651. ◆

Wild rice grading techniques are refinements of those already used by various growers and processors. (Photo courtesy of Uncle Ben's Long Grain and Wild Rice.)

Chance Discovery To Aid Muscle Research

ROB FLYNN

Pharmacologist Ronald T. Riley examines a model of cyclopiazonic acid. (K-3674-4)

It started out as just another ordinary analysis of yet another natural toxin. Ronald T. Riley, a research pharmacologist for the Agricultural Research Service in Athens, Georgia, was studying the toxicity to animals of the natural chemical cyclopiazonic acid (CPA).

As he pursued the research, Riley found that the way CPA affected animal cells was quite different from anything he had seen before.

By the time they were done, Riley and fellow researcher Douglas Goeger realized that CPA is potentially a valuable tool for understanding and possibly regulating skeletal and cardiac muscle contractions.

CPA is produced by certain species of the fungi *Penicillium* and *Aspergillus*. While conducting toxicity studies, the lab found that CPA accumulated in skeletal muscle and caused alterations in both the structure and function of muscle. Riley and Goeger observed that CPA caused numerous chemical alterations in membranes of muscle cells. It also changed the way in which calcium moved into and out of cells.

The precise regulation of calcium inside muscle fibers is critical for the proper function of the muscle.

Calcium is controlled by several different chemical systems. These systems regulate its concentration inside the cell and its entry into the cell. Therefore, the two scientists decided to study one system at a time, Riley says. Goeger began with the simplest first, an enzyme.

"This was a fortuitous decision since, as it turned out, CPA is a highly specific inhibitor of this one special enzyme that's responsible for the active movement of calcium within muscle fibers," says Goeger.

"In addition to CPA's use as a chemical probe for this enzyme, the finding could serve as a model for a whole new class of chemicals designed for drug treatments. This would include the animal diseases where there is a breakdown of the regulation of calcium within the cell," Riley adds.

Because Riley's research objectives are to assess the health risks from foodborne toxins, Riley and Goeger passed their results on to Anthony Martonosi of the College of Medicine at the State University of New York in Syracuse.

Martonosi had read Riley's and Goeger's scientific paper on the topic and asked Riley if the university laboratory could do further studies. Riley agreed.

Martonosi assigned a team of scientists to check Goeger's and Riley's theory that CPA could be used as an inhibitor of the calcium-dependent transport enzyme in muscle cells.

The medical researchers were indeed able to verify the ARS scientists' claim. Studies at the university showed that CPA could become a useful tool in determining the roles the calcium transport system plays during the contraction and relaxation of skeletal and cardiac muscle.

"The beauty of this is that CPA appears to be highly selective," says Riley. The movement of calcium within muscle fibers requires the expenditure of a large amount of energy, which comes from the breakdown of an energy-rich compound called ATP. Enzymes that break down ATP and use its stored energy to do things are called ATPases. The calcium transport enzyme is a calcium-dependent ATPase, but CPA locks up the enzyme so calcium can't be transported, Riley says.

"At a very low concentration, CPA is a specific inhibitor, but it appears not to deplete ATP levels," says Norbert W. Seidler, the lead scientist on the team working with Martonosi. "High levels of ATP could, in fact, protect against CPA toxicity." Seidler said the university is still testing CPA's potential as a medical tool.

Fungus-Produced Toxins

Interest in the compound began around 1982, when ARS researcher Richard Cole gave agency scientists at the Toxicology and Mycotoxin Research unit in Athens a sample of CPA to analyze for toxicity. Cole, research leader at the agency's National Peanut Research Laboratory in Dawson, Georgia, became interested in the compound after he learned of an outbreak of disease in turkeys in Britain in the early 1960's.

In each death, turkeys died with their legs extended. To Cole, that suggested the toxin responsible might have attacked the birds' nervous systems.

Cole learned later that the fungus *Aspergillus flavus* can produce both aflatoxin and CPA simultaneously.

With little information on CPA and its effects on animals, Cole turned to scientists at the Athens lab, where Riley was studying its effect on cell membranes.

"The toxicity of CPA to animals is difficult to summarize. In the hands of some researchers with some animal models, CPA appears to be relatively toxic, yet in other hands with the same animals it shows little or no toxicity," says William Norred, research leader of the group.

"CPA is not very toxic to muscle cells, liver cells, or kidney cells when compared to aflatoxin and other fungal toxins," Riley adds. "When I first looked at the structure of CPA, it appeared that it would have some effects on membrane function."

Cell membranes are vital because they act as barriers to the unregulated movement of nutrients or essential chemicals within the cell. The proteins within the membranes function as guards to regulate what can cross the border.

The calcium transport enzyme system, which is inhibited by CPA, is present in most if not all cells, Riley says. Because calcium is an important regulator of cell function, the processes that control calcium content within the cell are extremely vital to the well-being of the cell. This is especially true in muscle cells, which are extremely rich in this particular enzyme.

The enzyme is located in the membrane of the organelle within muscle cells, known as the sarcoplasmic reticulum. An organelle is a tiny cellular equivalent of an organ.

This organelle stores calcium while the muscle is relaxed and releases calcium into the cellular fluid where the proteins responsible for contraction are located.

This release of calcium occurs when the muscle is given a signal to contract. The muscle can relax only if the calcium is removed from contact with the proteins responsible for muscle contraction and stored once again in the organelle.

"CPA is not the only compound that can inhibit the calcium transport enzyme in muscles," Riley says, "but it is the only compound that is specific for this enzyme."

Riley says CPA stopped only calcium. This is important because it allows researchers to separate the processes responsible for calcium movement and the roles the calcium transport enzyme plays in regulating the contraction and relaxation of skeletal and cardiac muscles.

"When a scientist can change the function of just one enzyme without altering the activity of other enzymes, he or she can study the role of that one particular enzyme in the physiology of the whole system," Riley says.

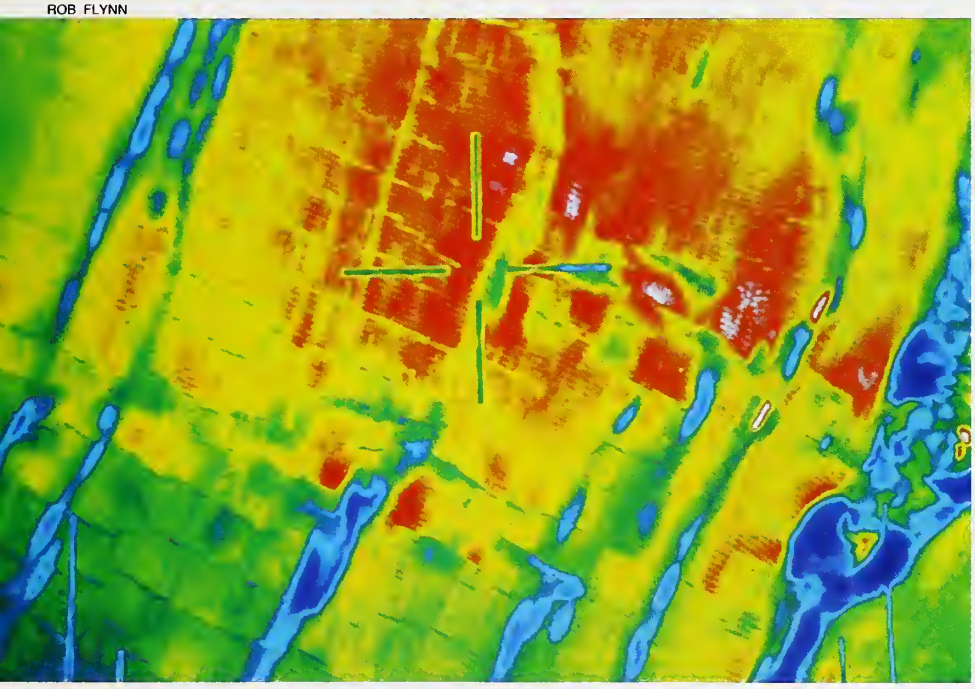
"If you want to know how the engine in your car works, you don't just open the hood and watch the engine run," he adds. "You individually check the operation of each component."

CPA might serve as more than just a tool to understand how the calcium transport enzyme regulates muscle movement. Riley thinks it might someday be used as a model to develop drugs to regulate muscle contraction, Riley says.

"A lot of fungal compounds have been found to be very valuable in medicine," he says. "It's not always just a matter of checking toxicity. That's what makes this research exciting."—By **Bruce Kinzel**, ARS.

Ronald T. Riley is in USDA-ARS Toxicology and Mycotoxin Research, P.O. Box 5677, Athens, GA 30613 (404) 546-3377. ◆

ROB FLYNN



Fluorescence microscope view of skeletal muscle tissue. The image has been computer-colorized to show levels of calcium contained in the sample tissue. (K-3675-2)

A Stick To Control Boll Weevils

Cotton farmers: there's a new way to combat the pesky boll weevil. It's a bait stick—4 feet tall by about three-quarters of an inch in diameter—that's being developed by the U.S. Department of Agriculture in cooperation with private industry.

Research agreements to improve on it have already been signed with Ciba-Geigy Corp., Greensboro, North Carolina, and Mobay Corp., Kansas City, Missouri.

"We call the bait stick an attracticide, since it both attracts and kills boll weevils," says Gerald H. McKibben, an entomologist with the USDA's Agricultural Research Service. "It's a simple concept, really, but it incorporates findings from years of research on boll weevil behavior and the boll weevil pheromone."

The new bait may help eliminate much of the $300-million-or-more cost in crop losses and control measures now incurred annually. "Normally, it takes several spray applications of organophosphate insecticide to control the weevil. But the new bait sticks use 100 times less insecticide—only 1 gram—per acre each application," explains McKibben, at the Boll Weevil Research Laboratory, Starkville, Mississippi.

The bait stick's cap is formed from a mixture of plastic, green pigment that's proven to attract weevils, a sex pheromone called Grandlure, a feeding stimulant that entices the insects to eat the bait, and an insecticide, cyfluthrin, that is very toxic to boll weevils, yet safe for mammals. According to McKibben the cap is friable, meaning weevils can chew it. But it also stands up to wet or hot weather, so the insecticide stays where it's supposed to.

PERRY A. RECH

It takes only one gram of insecticide located in the cap to make this bait stick an effective control for boll weevils. (K-3799-1)

The wooden stick is coated with a specially designed formulation that also kills the boll weevils. McKibben and colleagues developed it to kill those weevils that landed on the stick but didn't climb up to the bait and insecticide.

Besides being less expensive, the bait stick is easier to apply than other insecticides that are sprayed on cotton plants—it is simply stuck into cottonfields. It is also very specific to the target species.

The bait sticks are placed in cotton fields four times per season at a rate of one to four sticks per acre. McKibben says this works out to about 10 sticks per year per acre.

Presently, the wooden sticks with their plastic caps have to be picked up by hand. Cardboard stakes and biodegradeable caps are being considered, he says.

Field tests conducted last year showed that the sticks are a promising control for boll weevils, particularly during the early and late seasons. Putting out bait sticks in the early spring before the cotton plants flower lures overwintering female weevils. Otherwise they lay eggs that hatch into larvae that feed on cotton buds. McKibben found 100 to 150 dead weevils per week in aluminum pans placed under the cap to catch the dead insects. Later in the season, when cotton plants were defoliated for easier harvest, he found 200 to 300 weevils per day.

A second year of tests was run this past summer to compare the bait device, regular insecticide treatments, and a combination.

"We will see if the bait stick can be a useful addition to current programs to control or eradicate boll weevils," says James W. Smith, the laboratory's research leader.

So far, tests show 10 to 70 percent fewer boll weevils in fields with treated bait sticks. Encouraged, the researchers are planning future tests, including ones to see how long the bait is effective.—By **Dvora Aksler Konstant,** ARS.

Gerald H. McKibben is at the USDA-ARS Boll Weevil Research Laboratory, Starkville, MS 39762 (601) 323-2230. ◆

Learning Lessons on Reclamation

Strip-mined areas reclaimed for rangeland produce cattle weight gains that are just as good as those from cattle grazing undisturbed native range in the Northern Great Plains.

The end of a 5-year study put the finishing touch on research to determine the best methods of establishing productive vegetation on disturbed lands. These lands have limited available soil resources and are very susceptible to wind and water erosion. Therefore, the success of plant establishment and its continued growth is crucial to protecting the soil, says Gerald E. Schuman, ARS soil scientist at Cheyenne, Wyoming.

Schuman and other researchers at the High Plains Grasslands Research Station developed techniques to return disturbed rangeland to full production, then demonstrated that cattle can be grazed there without harm to the vegetation or loss in livestock production.

It turns out that animal grazing actually stimulates and encourages additional growth of grass rhizomes, enabling the plants to give greater soil protection by their increased density. Hoof action also helps break down standing dead grasses, releasing nutrients and hastening their recycling into new plant growth.

Other research findings from the station are already being applied. Wyoming's Department of Environmental Quality has spent nearly $57 million during the past 5 years reclaiming about 11,000 acres of land mined for bentonite and abandoned before state laws regulating mining took effect in 1973. The state used reclamation technology developed by Schuman and his coworkers.

Key to success was the addition of up to 60 tons per acre of wood chips, bark, and sawdust from lumber mills and 15 pounds of nitrogen fertilizer for each ton of wood waste. This was incorporated into the surface 12 to 18 inches of regraded bentonite spoil. The wood waste improved both physical and chemical characteristics of the spoil, enabling the revegetation of these derelict lands.

Like Wyoming, Montana and South Dakota have thousands of acres of abandoned bentonite-mined land. Together the three states produce 94 percent of the world's bentonite, used in oil and water well drilling, steel production, and hundreds of other applications. Montana has just begun to develop a program to reclaim abandoned bentonite lands.—By **Dennis Senft,** ARS.

Gerald E. Schuman is at the USDA-ARS High Plains Grasslands Research Station, 8408 Hildreth Road, Cheyenne, WY 82009 (307) 772-2433. ◆

GERALD SCHUMAN

Cattle grazing on rangeland reclaimed after strip mining have weight gains comparable to those obtained from undisturbed native range.

Viewing Anew the Structures of Life

Scientists at ARS' Electron Microscopy Laboratory (EML) in Beltsville, Maryland, are coming up with some new ways to see an otherwise invisible universe.

Take your standard everyday frozen-specimen holder for your standard everyday low-temperature scanning electron microscope: They modified the holder so that the specimen could be placed closer to the lens. The result: images having a higher resolution (sharper focus) and therefore more detail.

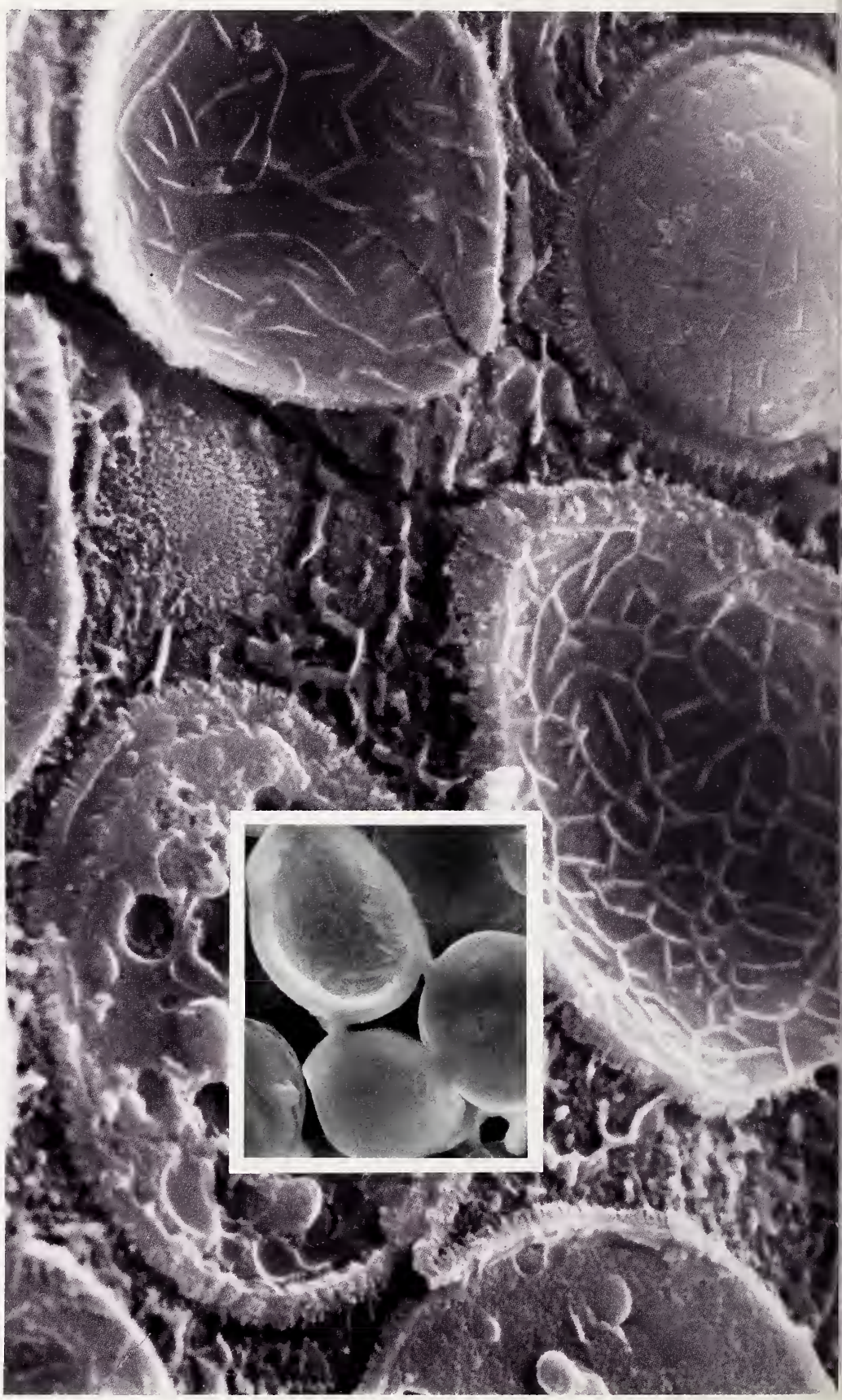
The scientists are also programming a computer to digitize and colorize black-and-white micrographs of plant cells to help analyze and quantify changing phenomena such as the effects of ozone on plants.

"And it won't be long before we can see individual atoms in molecules of DNA," says laboratory director William P. Wergin. That prediction is based on the lab's latest acquisition, a scanning tunneling microscope, which Wergin believes could revolutionize genetic research, once he and his colleagues perfect its use on biological materials.

"We're still experimenting," he says. "For example, we have to find a super-smooth substance on which to place the specimen so that its atoms can be distinguished from those in the background."

Most scanning tunneling microscopes are being used to examine metallic and other nonorganic surfaces. Only a few are being used in biological research, and so far no one has found a really good background for organic specimens.

Pyrolytic graphite and epitaxial gold are the best candidates, according to Wergin, who thinks it will be the gold.



The higher resolution gained by using a modified specimen holder results in a more detailed view of yeast than the one obtained with a conventional holder (inset).

"We need more time to be sure," Wergin says. "In any event, I know we'll be the first to dedicate a scanning tunneling microscope to agricultural science."

Electron microscopes have advanced considerably since they were first put in service over 50 years ago. But the working principles behind most electron microscopy remain the same: Electrons beamed at a target will either pass through some of it like an X-ray or excite electrons on the surface of the target, thereby causing these secondary electrons to jump off in a prescribed manner that can be converted into an image.

Instruments based on electrons passing through the target are called transmission electron microscopes; those based on an electron beam scanning the target and exciting secondary electrons are called scanning electron microscopes.

There are, of course, instruments using variations and combinations of these principles. The scanning tunneling microscope is different. It's based on the steady flow of electrical current between a slightly charged needle and the surface of the target it passes over.

"The needle theoretically narrows to one atom at its very tip," Wergin points out. "And the distance between the tip and the surface is less than a millionth of an inch. We're talking about a very precise and delicate operation."

Because a steady current will cause the distance between extremely close points to remain the same, the needle is forced to move up and down in response to bumps on the surface of the target. These bumps can be individual atoms. The corresponding movements of the needle are registered by a computer and translated into an image of the atoms.

"Specifically, it's the electron clouds or shells of atoms that we'll be looking at," Wergin points out. He is confident that the scanning tunneling microscope, once it's fully operational, will give scientists their first look at the atoms that make up DNA—thereby offering a three-dimensional view of DNA molecules.

PERRY A RECH

Electron Microscopy Laboratory director William Wergin places a specimen stage of epitaxial gold into position on a scanning tunnelling microscope. Gold is a super smooth mounting material needed to examine biological samples under extremely high magnification. (K-3798-1)

Such a view will be particularly useful to research on DNA sequencing in plants, according to ARS plant physiologist Jerome P. Miksche.

"It will help us confirm how molecules of DNA work together to generate a genetic code," he says. "So far, there's been a lot of guesswork and theory about DNA's molecular interactions. With the scanning tunneling microscope, we'll have some hard evidence."

Miksche, the ARS National Program Leader in plant physiology and biotechnology, is slated to direct USDA's Plant Genome Research Program. As a counterpart to the widely publicized human genome mapping project, the plant program would identify and locate all genetic DNA code elements for agriculturally important traits in plants.

"We're enthusiastic about the prospects of using scanning tunneling microscopy in plant genome mapping," he says, "but I don't want to imply that without it we couldn't proceed. We'll be using other kinds of electron microscopy as well."

This would include the laboratory's two transmission electron microscopes and two scanning electron microscopes. These instruments, along with the tunneling microscope and a computerized image scanning and analysis system, comprise the electron imaging capacity of the EML.

But the assets of the Electron Microscopy Laboratory are more than its hardware.

"We have some very innovative people working here," Wergin says, "and they're pushing back the technical limits of our equipment. They're getting images that weren't possible a short time ago."

One of the first projects for the EML involved the improvement of images made with low-temperature scanning electron microscopy.

In low-temperature microscopy, specimens are frozen rather than dehydrated. This prevents them from disintegrating or collapsing when viewed for long periods. It also eliminates the need for certain chemical treatments and drying procedures that can alter a specimen's appearance.

Unfortunately, low-temperature scanning electron microscopy has some inherent drawbacks—or at least

they were inherent until Wergin and his laboratory assistant, Eric F. Erbe, developed ways to overcome them.

For one, the shape and size of the standard cryostage (cold-retention platform) and holder for frozen specimens are less than ideal. They keep the specimen target too far from the microscope's electrical magnets and electron detectors (which focus the electron beam onto the target and collect the image-producing secondary electrons jumping off). This greatly reduces the resolution, or detail, of the images.

Also, freezing with liquid nitrogen is slow for larger specimens (in this case, larger means something about the size of a pollen grain) and generally causes cellular disruptions due to the formation of ice crystals.

And there's too much gold. The specimen is plated with an ultrafine coat of gold to supply secondary electrons for electron microscopic studies at any temperature. But the technique can obliterate fine structural details in frozen specimens.

After considerable experimentation, Wergin and Erbe modified the cryostage and specimen holder so that specimens could be placed between the electron microscope's upper and lower assemblies of electrical magnets and electron collectors.

The scientists also designed several tiny holders that could be mounted onto the larger standard holder. Their small mass and high thermal conductivity (they are made of gold) enable the specimens to be frozen more quickly, thus minimizing ice crystal formations.

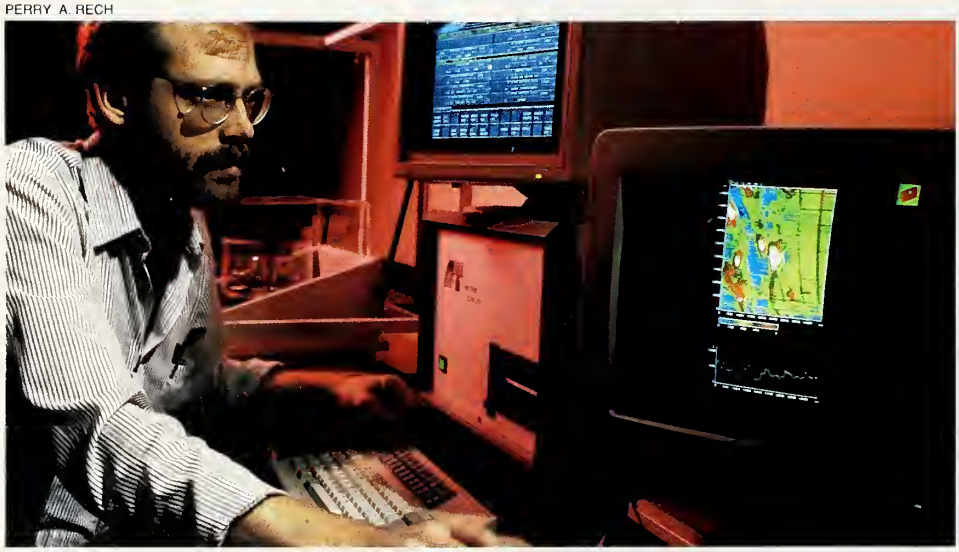
As for gold-plating the specimens, Wergin and Erbe switched to a vaporized mixture of carbon and platinum that laid down a coating only one-fourth as thick. Carbon and platinum had been used on specimens 15 years earlier, but the practice was abandoned as unnecessary and too expensive. Back then, no one had anticipated the possibility of high-resolution images from low-temperature electron microscopy.

The holder modifications and plating techniques developed by Wergin and Erbe have produced a tenfold increase in image resolution for low-temperature scanning electron microscopy.

And because some of the mechanical and chemical procedures previously necessary in this type of microscopy can now be minimized or avoided, say the scientists, the images come closer to depicting the true nature of biological structures.

Computer-colorized images of plant chloroplasts. Above: different cell membranes (magnified 30,000 times) appear in shades of red and blue. Right: starch deposits (9,000 X) show up as gap in an otherwise green image.

PERRY A. RECH

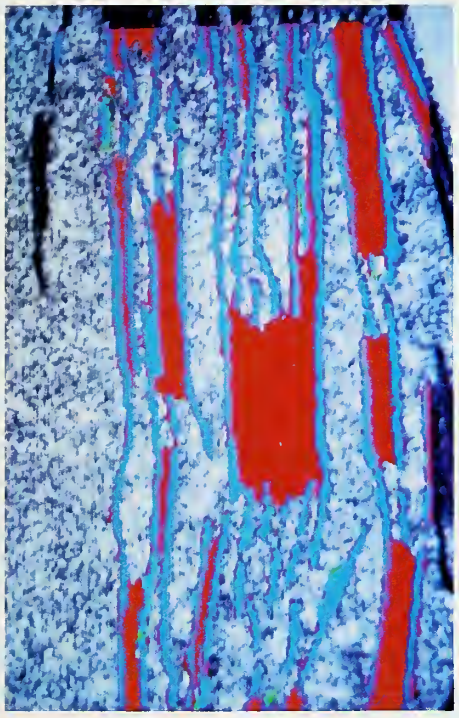


Biological laboratory technician Chris Pooley views the monitoring screen of a scanning tunnelling microscope. (K-3796-4)

Another project at the EML involves development of computer software for digitizing and colorizing images from optical as well as electron microscopes.

In a process quite similar to the colorization of old black-and-white movies, a computerized light-measuring system scans the microscope images and assigns a numerical value to each pixel (a point-sized unit of the image) according to its shade of grey. The exact location and value of each pixel can be recorded for statistical and quantitative analyses. The pixels can also be reproduced as a color micrograph for easier visual examination.

"We've done both," says laboratory technician Chris Pooley, who



wrote an image analysis program to handle membrane changes in cell chloroplasts. Called CHAP, for Chloroplast Analysis Program, it's the first of what Wergin expects to be several such programs created by the EML for microscopic image analysis.

Chloroplasts are found in the cells of all green plants. Using sunlight, they convert carbon dioxide taken in by the plants to oxygen. Because of their high sensitivity to environmental change, these cellular organelles have become an important subject of research on how ozone and other pollutants and elevated levels of carbon dioxide affect plant life.

"We've got artwork," Pooley says, pointing to a wall display of enlarged computer-colorized micrographs of chloroplasts, "and we've got data. Our program can assign colors to the images for visual analysis, and it can produce useful data based on the grid coordinates of each pixel."

Recently introduced by Wergin and Pooley at the 13th International Congress for Electron Microscopy, CHAP is able to calculate the size of chloroplasts and statistically characterize several of their structural features and conditions.

"This program will make it a lot easier to interpret the results of some of our greenhouse experiments in terms of chloroplast structures and related functions," says Wergin.

According to one ARS scientist looking at the effects of air pollution on plants, CHAP could also lead to a more effective use of electron microscopy in large-scale field studies of plant life and its overall response to changes in the atmosphere.

"With this program," says Walter Heck, head of air quality/plant response research for ARS at North Carolina State University in Raleigh, "we could analyze thousands of chloroplast images for data relevant to whole regions of the country. And if we can link specific changes in chloroplast structures with specific air pollutants on a regional basis, then I think the regulatory and scientific implications alike will be considerable."—By **Stephen Carl Miller,** ARS.

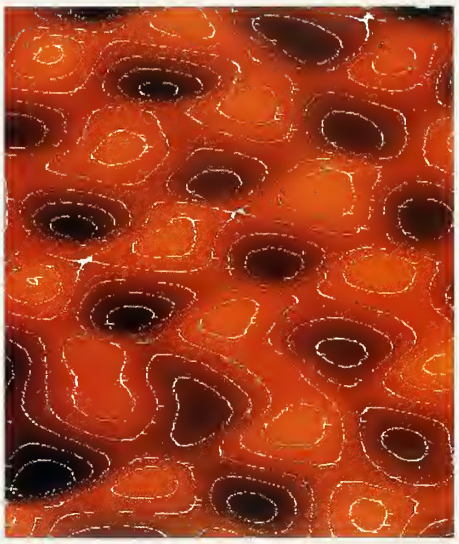
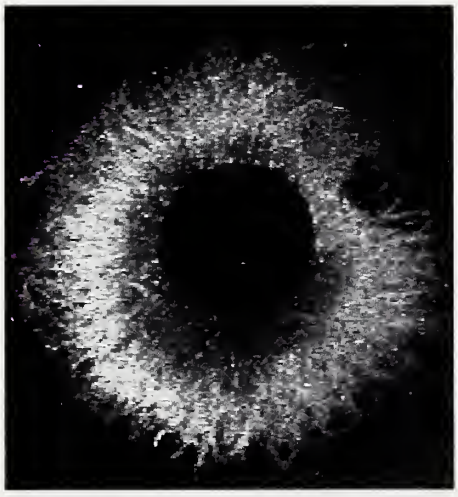


Image produced by a scanning tunnelling microscope illustrates the relative height of electron shells in carbon atoms. Distance between white contour lines is less than one millionth of an inch.

William P. Wergin, Eric F. Erbe, and Christopher Pooley are at the ARS Electron Microscopy Laboratory, 177-B, Beltsville Agricultural Research Center-East, Beltsville, MD 20705 (301) 344-3527. ◆



Microscopic image of a tomato root (30 X) shows the internal cells of the root, as well as protruding root hairs. The same cross section of a tomato root shown at left is illustrated in the form of an X-ray map. X-ray mapping allows researchers to track various elements in specimens.

Flax Message: New Variety for the Health Conscious

Omega is the newest high-yielding flax variety suited for breadmaking. It may become a hit all the way from the farm to dinner tables in the United States and abroad in the early 1990's as seed becomes available to growers. The variety gets its name from omega-3, a family of fatty acids that are abundant in flax and fish oils.

In contrast to the brown seeds of most flax varieties, Omega's seeds with a golden tint look somewhat similar to sesame seeds.

Some of the 64,000 tons of flax seed currently marketed to satisfy European palates is sprinkled whole onto salads and other foods. But most is ground and blended into flour, where it adds a nutty taste to bread and contributes a whole wheat appearance and texture. Such breads could become more popular as people seek health benefits from the seed's fiber and oil, says Jack F. Carter, president of the Flax Institute, Fargo, North Dakota.

In agronomic tests, geneticists Jerry F. Miller of ARS and James J. Hammond of North Dakota State University, Fargo, found that Omega produced oil yields similar to those of brown-seeded varieties and 32 percent more than Foster. Foster is the only other yellow-seeded flax recommended for planting in North and South Dakota.

Omega is distinguished as the first yellow-seeded variety with multiple genes for resisting all prevalent races of rust diseases in North America.

Brown-seeded varieties are intended mainly for linseed oil used in industrial products such as paints. The United States now produces about a third of its own flax and meets most of its remaining needs with imports from Canada.

Flax seed is sold in health food stores, and a few bakeries now market bread containing flax.

The seed's omega-3 fatty acid, known as alpha-linolenic, is also present in soybean and some other vegetable oils, although in much lower amounts. This fatty acid can be converted by the human body to fatty acids like those in fish oil. Some researchers have suggested that consuming moderate amounts of omega-3 fatty acids and avoiding high-fat diets may help reduce a person's tendency to develop cardiovascular disease.

How soon can consumers buy breads containing Omega flax seeds or bake such breads in their own ovens? Probably not for 2 years or more, since less than 100 acres of certified seed was planted in 1990. Large amounts cannot reach the market until 1992.—By **Ben Hardin,** ARS.

Jerry F. Miller is in USDA-ARS Oilseeds Research, Northern Crop Science Laboratory, P.O. Box 5677 University Station, Fargo, ND 58105 (701) 239-1321. ◆

Insect Gene Mapping

"Know thy enemy," an old proverb admonishes, and Walter Tabachnick has taken this advice to heart.

Tabachnick, an ARS entomologist at ARS' Arthropod-Borne Animal Diseases Research Laboratory in Laramie, Wyoming, has set out to understand the genetic makeup of *Culicoides variipennis,* a biting midge primarily responsible for spreading a disease of ruminants known as bluetongue.

Bluetongue, so named because sheep's tongues may turn blue in advanced stages of the disease, costs livestock producers millions of dollars in losses every year. This debilitating disease affects sheep, cattle, and ruminant wildlife. Countries that are bluetongue free ban our untested breeding stock and germplasm, a potential market loss that is estimated at more than $120 million a year.

Initially, Tabachnick hopes to identify those genes that make some *Culicoides* excellent carriers of bluetongue whereas others are poor transmitters. So far, he has bred insects that vary widely in their ability to spread bluetongue disease. In some of his laboratory populations, up to 90 percent of the insects can carry the virus; in others only 5 to 10 percent.

Using state-of-the-art techniques including DNA restriction fragment length polymorphisms, Tabachnick leads the field in learning how subspecies differ in their genetic makeup.

Such knowledge should help in controlling the spread of other insect-borne viruses, perhaps including those that cause human diseases, such as yellow fever, encephalitis, and dengue, and plant diseases caused by potato leaf roll and tobacco mosaic viruses.—By **Dennis Senft,** ARS.

Walter Tabachnick is with the USDA-ARS Arthropod-Borne Animal Diseases Research Laboratory, P.O. Box 3965, University Station, University of Wyoming, Laramie, WY 822071-3965 (307) 776-0313. ◆

Avoiding Cataracts

Worldwide, 50 million people suffer from clouded vision due to cataracts. In the United States alone, about 1.4 million people—mostly the elderly—underwent cataract surgery during the 1990 fiscal year. Medicare paid for 1.2 million of those surgeries at a staggering cost of nearly $3.2 billion. The cost in quality of life is even greater.

Mounting evidence suggests that many of these operations may be delayed or prevented if people consumed more fruits and vegetables and more of the antioxidant vitamins.

Researchers with ARS' Human Nutrition Research Center on Aging at Tufts and the Brigham and Women's Hospital eye clinic recently took the most comprehensive look at the relationship between cataracts and diet in 112 people between the ages of 40 and 70. Seventy-seven of the participants had at least one cataract; 35 had clear lenses.

Both groups filled out a lengthy questionnaire detailing how often they consumed various foods; they provided a history of their supplement use as well as blood samples. Although small in scale as epidemiology studies go, when the data were put through statistical analyses, significant differences appeared:

"Study subjects who had cataracts didn't eat as many fruits and vegetables," says Paul Jacques with the ARS/Tufts center's epidemiology program. Those who consumed less than 1.5 servings of fruit or fruit juice per day or less than two servings of vegetables or vegetable juice were three and a half times more likely to have cataracts. And those who fell short in both categories had a 5.7-times-higher incidence.

"These are arbitrary cutoffs," says Jacques. "Getting just two servings of vegetables a day probably isn't the optimum. But those subjects who fell below two servings appear to be at substantially increased risk."

The study also found a strong link between cataract incidence and antioxidants, particularly vitamin C. Antioxidants are substances that help detoxify cell-damaging substances.

Participants whose vitamin C intake was in the lowest 20 percent—and that included people who reported getting more than the 60 milligram RDA—had 4 times the occurrence of cataracts, says Jacques. A similar relationship emerged between vitamin C levels in their plasma and cataract incidence.

The statistics also showed, for the first time, a relationship between cataract occurrence and plasma levels of carotenoids—the red, yellow, and orange plant pigments, including beta carotene, says Jacques.

Cataracts were 5.6 times more prevalent among those with the lowest plasma levels. But they were not tied to the participant's intake of beta carotene, which accounts for only about 20 percent of the total carotenoids in the diet, he says. Carotenoids are abundant in the dark-green leafy vegetables as well as the orange and red fruits and vegetables—tomatoes, peaches, squash, and, of course, carrots.—By **Judy McBride,** ARS.

Paul F. Jacques is with the USDA-ARS Human Nutrition Research Center on Aging at Tufts University, 711 Washington Street, Boston, MA 02111 (617) 556-3322. ◆

Higher Producing Honey Bees

A weighing scale, a method for suspending a beehive on it, and some persistence. Those are the only investments needed to breed better honey producers, thanks to a new technique that beekeepers will find easier and cheaper than most breeding programs.

The new program centers on hive weight gain. How much weight a honey bee hive gains over the honey season indicates how much honey the bees are making.

New studies show that beekeepers can breed high-weight-gain strains of bees—and therefore good honey producers—simply by selecting the queen. Usually, breeders select which males sire new generations by artificially inseminating queens or by bringing males and females to isolated "mating stations." These techniques are difficult, and time-consuming.

"I wanted to know if you could alter the honey-producing trait by selecting only the queen," says ARS entomologist Nicholas W. Calderone.

After a 3-year study begun at Ohio State University and finished at the ARS Bee Research lab at Beltsville, Maryland, Calderone got his answer: a definite "yes."

Calderone weighed hives at the start of the honey production season and then again later, choosing the ones that gained the most weight and those that gained the least.

From these, he reared queens that mated at random with males and produced new brood.

Calderone did this for 3 seasons. At the study's end, colonies from the high-weight-gain strain gained an average of three times more weight than colonies from the low-weight-gain strain. That showed that the trait is definitely something a beekeeper can improve by working with just the queens.

"Of course, if producers select both males and females, they will make faster progress," Calderone says. "But I wanted to see if we could get anywhere when we control just the queen."

Another important finding from the study: This tendency to make a hive heavy with honey can be bred into a population in half the time required in most breeding programs.

That's because early-season weight gain correlates very well to total weight gain, Calderone says. In his tests, hives that gained well after just 1 month gained well after the whole season.

So a beekeeper can, with confidence, make selections early on and rear queens from good hives.

Usually, beekeepers wait until fall to evaluate colonies, so selected queens will not be reared and reproducing until the next year. That would double the amount of time needed for breeding.

"Beekeepers may find this technique worth doing because they need not control the paternal contribution and because they can select and rear offspring in the same season," he says.

He points out that selected strains may not produce hoards of additional honey. But an increase in each colony's productivity of just 10 pounds of honey —about $5 worth—adds up for commercial beekeepers who may have from 1,000 to 40,000 colonies, Calderone notes. "It could mean the difference between staying in business and not staying in business."

It also lets the commercial beekeeper produce more honey with a lower capital investment in equipment.—By **Jessica Morrison Silva,** ARS.

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Just off press: *"Seeds for Our Future. The U.S. National Plant Germplasm System," a booklet describing NPGS, its role, and its history, may be ordered from Henry L. Shands, USDA-ARS, Room 140, Bldg. 005, BARC-West, Beltsville, MD 20705.*

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More than 33 years after their accidental release in Brazil, Africanized bees reach Texas.